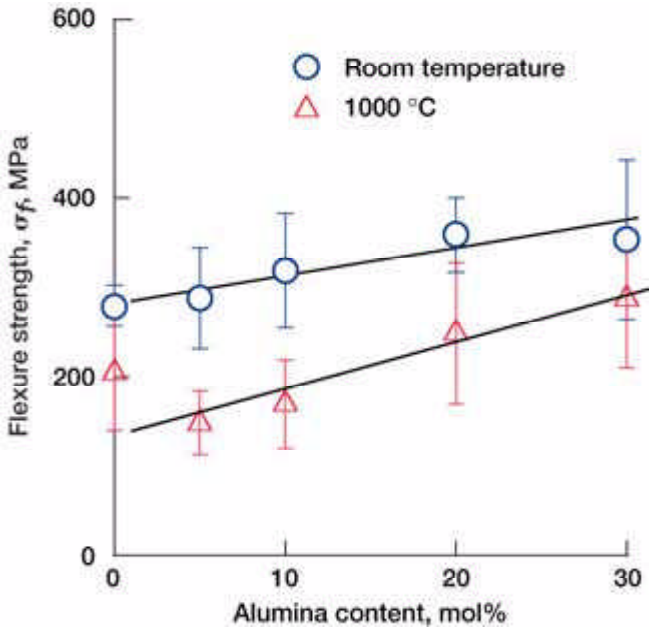
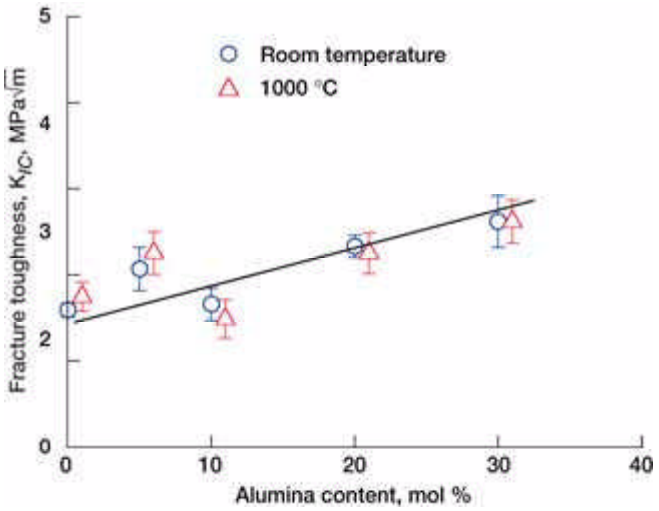
Strength and Fracture Toughness of Solid Oxide Fuel Cell Electrolyte Material Improved

Solid oxide fuel cells (SOFC) are being developed for various applications in the automobile, power-generation, and aeronautics industries. Recently, the NASA Glenn Research Center has been exploring the possibility of using SOFC's for aeropropulsion under its Zero Carbon Dioxide Emission Technology (ZCET) Program. 10-mol% yttria-stabilized zirconia (10YSZ) is a very good anionic conductor at high temperatures and is, therefore, used as an oxygen solid electrolyte in SOFC. However, it has a high thermal expansion coefficient, low thermal shock resistance, low fracture toughness, and poor mechanical strength. For aeronautic applications, the thin ceramic electrolyte membrane of the SOFC needs to be strong and tough. Therefore, we have been investigating the possibility of enhancing the strength and fracture toughness of the 10YSZ electrolyte without degrading its electrical conductivity to an appreciable extent.





Left: Effect of alumina additions on the strength of 10YSZ electrolyte at room temperature and 1000 °C measured in four-point flexure in ambient atmosphere with 20/40-mm spans (ASTM C1161 and 1211) at a loading rate of 50 MPa/sec in ambient air. Right: Effect of alumina additions on fracture toughness of 10YSZ electrolyte at room temperature and 1000 °C. Measurements were conducted in four-point flexure with 20/40-mm spans by the single-edge V-notched beam method in ambient atmosphere at a loading rate of 0.5 mm/min.

We recently demonstrated that the addition of alumina to zirconia electrolyte increases its strength as well as its fracture toughness. Zirconia-alumina composites containing 0 to 30 mol% of alumina were fabricated by hot pressing. The hot pressing procedure was developed and various hot pressing parameters were optimized, resulting in dense, crack-free panels of composite materials. Cubic zirconia and α-alumina were the only phases detected, indicating that there was no chemical reaction between the constituents during hot pressing at elevated temperatures. Flexure strength σ_f and fracture toughness K_{IC} of the various zirconia-alumina composites were measured at room temperature as well as at 1000 °C in air. Both properties showed systematic improvement with increased alumina addition at room temperature and at 1000 °C. Use of these modified electrolytes with improved strength and fracture toughness should prolong the life and enhance the performance of SOFC in aeronautics and other applications.

Bibliography

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